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Non-Stationary Inflation and the Markup:
an Overview of the Research and some Implications for Policy

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Abstract

This paper reports on research into the negative relationship between inflation and the markup. It is argued that this relationship can be thought of as 'long-run' in nature which suggests that inflation has a persistent effect on the markup and, therefore, the real wage. A 'rule of thumb' from the estimates indicate that a 10 percentage point increase in inflation (as occurred worldwide in the 1970s) is associated with around a 7 per cent fall in the markup accompanied by a similar increase in the real wage. It is argued that movements of this magnitude in the markup and the real wage will have important implications for a range of economic outcomes such as unemployment, employment and investment.

Keywords: Inflation, Wages, Prices, Markup, Monetary Policy, Competition.

JEL Classification: C22, C32, C52, E24, E31

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1 INTRODUCTION

In the last half of the 1980s while working in the Research Department of the Reserve Bank of Australia I observed that for the major western economies, the markup of price on unit labour costs was high when inflation was low and *visa versa*.[1] The markup can be thought of as the profit share of national income or an aggregate measure of the profitability of firms. Importantly, the shifts in the markup associated with changes in the general rate of inflation seem to persist even after 10 or 15 years of high and relatively stable inflation.

This observation presents a puzzle for standard macroeconomics as persistently high inflation should not be associated with a *persistent* shift in a 'real' variable such as the markup. Instead standard macroeconomics predicts that the relationship between inflation and the markup should be fleeting and the markup should quickly return to some long-run level. Consequently, the markup should bear no relation to the rate of inflation in the long-run given enough time and inflation is stable.

The puzzle is not the negative inflation-markup relationship itself as this has been identified either directly or indirectly in a number of empirical papers.[2] The puzzle is how persistent the impact of inflation on the markup is. In other words, if the rate of inflation is either stable and high (as in the 1970s and early 1980s), or stable and low (as since the mid-1990s), standard macroeconomics would predict that the markup should return to the same long-run value. It is easy to show empirically that this has not been the case. Persistent shifts in the rate of inflation are associated with persistent shifts in the level of the markup and that the relationship appears 'permanent' in some sense even after long periods of time.

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1 The logarithm of the markup, mu, is defined as $mu \equiv p - \sum_{i=1}^{k} \psi_i c_i$ where p and the c_i's are the logarithms of prices and the costs of production respectively, $\sum_{i=1}^{k} \psi_i = 1$ where k is the number of inputs. If the latter condition is not satisfied then the relationship between prices and costs cannot be termed the markup. At an aggregate level where the only inputs are labour and capital, one measure of the markup is: $mu = (p + y) - (w + l)$ where y, w, and l, are constant price output, the average wage rate and the level of employment respectively. The markup in this case is equivalent to the inverse of labour's share of national income.

2 For example see Richards and Stevens (1987), Bénabou (1992), Franz and Gordon (1993), Cockerell and Russell (1995), de Brouwer and Ericsson (1998), and Batini, Jackson, and Nickell (2000) and *inter alia*.

The persistence of shifts in the markup and the ‘permanence’ of the inflation-markup relationship are demonstrated in a series of mainly empirical papers with my principle co-author Professor Banerjee (European University Institute and the University of Oxford). We identify a negative long-run relationship between inflation and the markup using data for the United States, United Kingdom, Canada, West Germany, France, Italy, Australia and the Euro area.[3] The relationship can be identified from the early 1950s to the beginning of the 21st Century using industry or economy wide data.

Is it important that the markup and inflation are negatively related? The answer is straightforward and yes. Persistent shifts in inflation that lead to persistent shifts in the markup are likely to affect a range of important economic outcomes. For example, a ‘rule-of-thumb’ from the empirical estimates so far is that a 10 percentage point increase in the general rate of inflation (as occurred in many developed economies in the 1970s) is associated with around a 7 percent increase in the real wage relative to the level of productivity. Movements in the real wage of this magnitude are likely to severely reduce employment and increase unemployment. Furthermore, the associated reduction in the profit share is likely to lead to falls in investment and the subsequent reduction in the capital stock will lower productivity and standards of living. These effects on the economy are all the more important because they would persist for as long as the high inflation persists.

The remainder of this paper considers four issues that the research focuses on; namely, (i) inflation is non-stationary; (ii) estimating the negative inflation-markup relationship; (iii) explaining the relationship; and (iv) some policy implications of the relationship.

2 INFLATION IS NON-STATIONARY

There are very, very few statements that we can be confident about in macroeconomics but one must be the long-run rate of inflation has not been constant over the past 50 years. That is, inflation is not a stationary variable with a constant mean. Leaving aside evidence from unit root tests that are notoriously unreliable, the statement logically follows by considering the implications if the converse of this statement is true.[4] That is, if inflation is stationary

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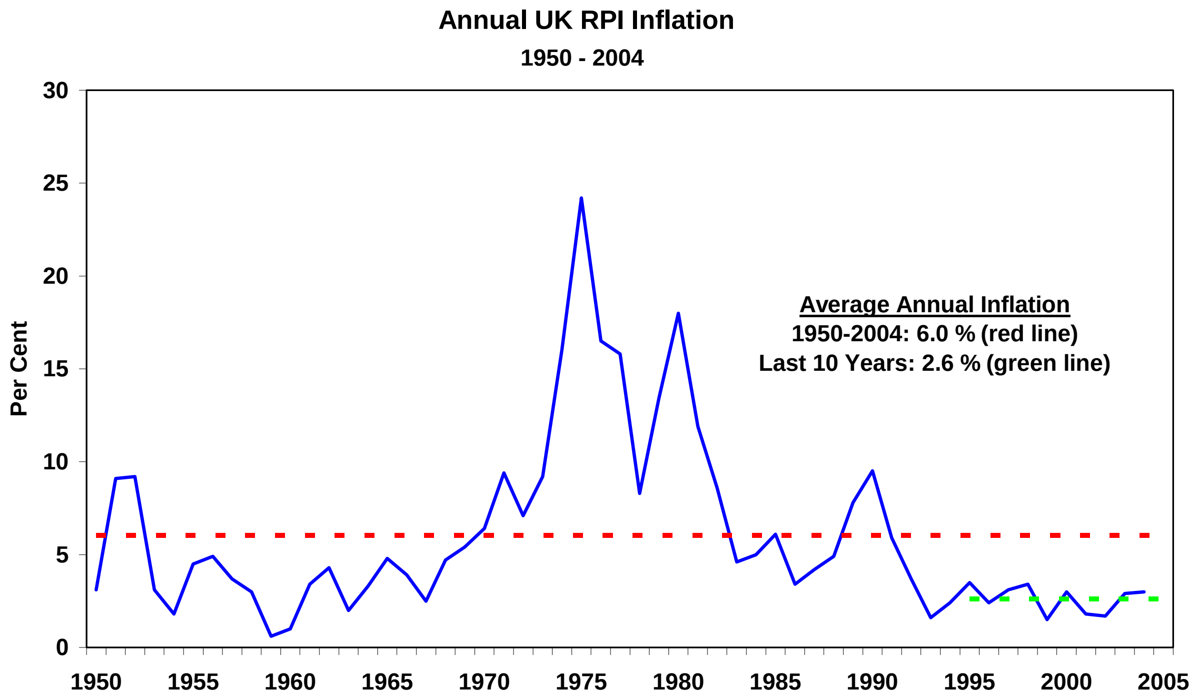
3 The long-run is in the sense of Engle and Granger (1987). For the estimates see Banerjee, Cockerell and Russell (2001), and Banerjee and Russell (2001a, 2001b, 2004, 2005).

4 Unit root tests are well known to have low power and in the hands of a ‘skilled’ practitioner can find inflation to be either a stationary or a non-stationary process.

with a constant mean then there is a unique long-run rate of inflation and this would imply that:

(i) The question 'what is the long-run rate of inflation?' is valid. Furthermore, the answer must be invariant to whether you are standing in 1950, 1974, 1989, 1995 or 2005 and if you are looking forward or backward. The usual method of estimating the long-run rate of inflation is to simply measure the average rate of inflation over the sample under consideration. For the period 1950-2004, UK RPI (all items) annual inflation had a mean of around 6 per cent compared with a rate of around 2 ½ per cent for the last ten years (see graph 1). If there was a constant long-run rate of inflation then this suggests that there should be considerable upward pressure on inflation at the moment. Furthermore, it implies that the Bank's inflation target is inconsistent with this measure of the long-run rate of inflation. The usual response to this argument is to say there are 'breaks' in the inflation series in the 1970s, 1980s and 1990s. This response simply acknowledges that there has been a shift in the mean rate of inflation i.e. the long-run rate of inflation is not constant.

Graph 1



(ii) Institutional arrangements have no impact on the long-run rate of inflation. For example, the targeting of inflation, money or exchange rates, the level of independence of the central bank, or the personalities of the governors of the central bank (i.e. Volker, Greenspan, or Bernanke) will have no effect on the constant long-run rate of inflation. Instead, these issues can only influence how fast inflation returns to the long-run rate of inflation and not the rate itself. Furthermore, it implies that making the Bank of England independent with an inflation target has in no way helped to maintain annual inflation at around 2 ½ per cent over the last 10 years compared with an average rate of 9 per cent for the 25 years before that.

(iii) All the monetary economics and macroeconomics literature describing the dynamics associated with changes in the long-run rate of money growth would be at best 'misplaced' as only one growth rate of money will be consistent with the long-run rate of inflation.

(iv) The long-run Phillips curve in an applied sense is a single point as there is only one rate of inflation in the long-run. There is also only one short-run Phillips curve as there is only one long-run rate of inflation. Furthermore, any theoretical discussion of the dynamics that an economy will display during the transition between different rates of inflation in the long run is meaningless as the economy never experiences any change in the long-run rate of inflation.

Unless we are willing to accept what is implied by a constant long-run rate of inflation, we must conclude that inflation does not have a constant mean. In other words, inflation is non-stationary.

3 ESTIMATING THE NEGATIVE INFLATION-MARKUP RELATIONSHIP

There are two broad ways to model non-stationary inflation. The first is to assume inflation is stationary with shifting means. The usual way to proceed here is to include a shift dummy that coincides with periods when it is thought that the mean rate of inflation has shifted. The problem with this approach is that the inflation series will be 'rendered' stationary with the inclusion of just a few dummies due to the well documented low power of unit root tests. These 'few' dummies will not represent all the shifts in mean inflation over the sample and they will be hard to interpret in an economic sense.

The second way to proceed is to assume that inflation behaves as if it is an integrated variable. This cannot be strictly true as inflation in most economies appears to be bounded above at some positive rate and below at, or near, zero. However, this approach has two major advantages. First, it allows us to investigate directly the long-run relationship between inflation and the markup. And second, as the number of breaks in the mean rate of inflation increase, the stationary with shifting means model converges on the integrated model. So while the 'true' statistical behaviour of inflation is most likely stationary with a very frequent and unknown shifting mean, our estimation of the relationship proceeds assuming that inflation is an integrated variable of order 1.

In any case, estimates of the relationship derived from models that assume inflation is stationary with shifting means are very similar in magnitude, and the same in an economic and policy sense, as those derived from models that assume inflation is an integrated variable. In other words, it is not important how you proceed in estimating the negative inflation-markup relationship. What is important is that you model inflation as a non-stationary statistical process and that you interpret the estimated relationship as between the markup and different mean rates of inflation.

3.1 The General Inflation-Markup Model

Given the assumption that inflation is an integrated variable of order 1, the long-run structure of our general model is given by: [5]

$$mu = p - \phi ulc - (1-\phi)pm = q - \lambda \Delta p \qquad (1)$$

where, ulc is unit labour costs, pm is the price per unit of imports, q is the 'gross' markup, and mu is the markup 'net' of the cost of inflation.[6] Lower case variables are in natural logarithms. The inflation cost coefficient λ is greater than zero and $0 \le \phi \le 1$. The coefficients ϕ and $1-\phi$ are the long-run price elasticities with respect to unit labour costs and import prices respectively. Long-run homogeneity is imposed with these coefficients summing to one.[7] That is, for a given rate of inflation, an increase in either unit labour costs

5 The form of the long-run price equation is a dynamic generalisation of that estimated in de Brouwer and Ericsson (1998). See Banerjee, Cockerell and Russell (2001) for the derivation of (1) from a standard Layard/Nickell imperfect competition model.

6 The assumption of a linear relationship between inflation and the markup in (1) cannot strictly be true since the markup approaches zero as inflation tends to an infinite rate. However, we assume that over the smaller range of values of inflation considered by us, the log linear relationship is a good approximation.

7 Note that without linear homogeneity q does not represent the 'gross' markup of prices on costs.

or import prices will see prices fully adjust in the long-run to leave the markup unchanged.[8] Equation (1) collapses to the standard imperfect competition markup model of prices when $\lambda = 0$. In our more general case when $\lambda \neq 0$, inflation imposes costs on firms and the markup net of the cost of inflation is reduced.

Assuming that inflation is I(1) implies that prices, unit labour costs and import prices are all I(2) variables and so system estimates of (1) is somewhat tricky. Banerjee, Cockerell and Russell (2001) and Banerjee and Russell (2001a) estimate the model using I(2) methods developed by Johansen (1995a, b).[9] We find in these papers that the I(2) levels of prices and costs cointegrate to the markup which is I(1) and then there is a negative cointegrating (or long-run) relationship between the markup and inflation (both of which are I(1)).

An alternative way to proceed is to test for and then impose linear homogeneity on (1). In this case we can write the markup defined in (1) as the weighted sum of the markup of price on unit labour costs, $muulc$, and the 'real exchange rate', rer. When the markup is calculated in this way using a measure of consumer prices, we write (1) as:

$$mu = muulc + \delta rer = q - \lambda \Delta p \tag{2}$$

where $muulc = p - ulc$ and $rer = p - pm$.[10] The estimated markup written in the form of (1) with linear homogeneity imposed is then:

$$mu = p - \frac{1}{1+\phi} ulc - \left(1 - \frac{1}{1+\phi}\right) pm \tag{3}$$

The advantage of (3) is that it can be estimated using familiar I(1) system methods.

Estimation of the system is conditioned on two predetermined (stationary) variables. The first are a number of spike intervention dummies to capture the sometimes erratic short-run wage and price behaviour of firms and labour. This is especially the case during the OPEC oil

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8 When the general level of inflation increases we will observe in the data that increases in costs are not fully reflected in higher prices. This necessarily follows as the markup falls with higher inflation and this can only come about if increases in unit labour costs are not fully passed though into higher prices. Consequently, linear homogeneity is evident in the data only when there is no change in the long-run rate of inflation.

9 See also Haldrup (1998) and Paruolo (1996).

10 The term rer may be referred to as the 'real exchange rate' due to the similarity to the relative price of traded and non-traded goods used by Swan (1963) as a measure of the real exchange rate.

price shocks and large shifts in exchange rates and tax regimes. The second is the log change in the unemployment rate to represent the business cycle in the model.

An alternative specification of the empirical model would be to include the level of unemployment in the cointegrating space as an endogenous or exogenous variable. However, it is not clear what the economic relationship between the markup, inflation and the level of unemployment would be in the long-run. There is some indication that the relationship is highly non-linear and may differ substantially among economies. Furthermore, such an inclusion would alter the interpretation of this variable from that of an indicator of the business cycle to one of an excess supply of labour. It was therefore decided to allow for the effects of the business cycle by conditioning on a stationary pre-determined variable given by the log change in the unemployment rate and its lags.

3.2 Estimates of the Long-run Inflation-Markup Relationship

With Anindya Banerjee (and others) we identify the negative long-run relationship using the data for the G7 economies (excluding Japan) and Australia.[11] Estimates of the long-run inflation-markup relationship from these papers are summarised in Table 1.[12] The right hand column reports the estimates of the inflation cost coefficient, λ, and shows considerable similarity across countries and data sets. The long-run relationship is remarkably robust to levels of aggregation (industry versus economy wide data), data frequency (quarterly versus annual data) and time periods. The estimates suggest ‘a rule of thumb’ where an increase of one percentage point in the long-run rate of annual inflation will be associated with a fall in the markup of around 0.7 of one percent.

The United Kingdom results from Banerjee and Russell (2001a) are shown graphically in Graph 1. These results are typical of those reported in Table 1. The solid line, *LR*, in the graph represents the estimated long-run relationship using quarterly United Kingdom data for the period December 1961 to March 1997. The actual observations of inflation and the markup are also shown on the graph. Note that the slope of the graph is about – 0.6 (i.e. a 10 percentage point increase in inflation is associated with about a 6 per cent fall in the markup)

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11 Banerjee, Cockerell and Russell (2001), Banerjee and Russell (2001a, 2001b, 2004, 2005), Russell and Banerjee (2006) and Banerjee, Mizen and Russell (2006).

12 For comparison, Table 2 provides implied estimates of the long-run relationship that can be derived from estimated inflation equations that assume inflation is a stationary variable.

and this is equal to the long-run inflation coefficient reported in the last column of Table 1 for the United Kingdom.

One explanation of the negative long-run relationship in the data is that the 1970s were a period when supply shocks from the energy and labour markets were very prevalent. The low markup, therefore, simply reflects the lags in price adjustment following the shocks. The adjustment appears to be very slow for economies with little or no price controls. The relatively low markup persists for around 10 years following the shocks and the markup does not fully recover until the economy experiences low inflation again (i.e. there is a reduction in the mean rate of inflation).

Another explanation of the negative relationship is that the business cycle has a positive relationship with inflation and a negative relationship with the markup. Consequently, the negative inflation-markup relationship is simply due to the simultaneous influence of the business cycle on both variables.

In response to these two explanations of the negative inflation-markup relationship the realisations of the markup and inflation for five distinct inflationary periods are indicated by different symbols in Graph 1. If the 'supply shocks' and 'business cycle' arguments are correct then different mean levels of inflation would not affect the behaviour of the markup. Consequently, realisations of the markup and inflation from different periods of inflation would be distributed evenly along the entire curve in Graph 1. This however is not the case.

It may be seen clearly from the graph that if the data were subdivided into periods of inflation with different means, the associated mean levels of the markup are different. For example, the early 1960s are shown as crosses on Graph 1 and we see that the markup is high during a period of low inflation. The late 1960s and early 1970s are shown as squares and was a period of slightly higher inflation and a slightly lower markup. We can follow the relationship through each inflationary period until the observations return to hover around low inflation and a high markup for the period following the early 1990s recession.

The ability to separate actual observations of inflation and the markup into distinct periods with higher inflation associated with a lower markup and *vice versa*, is further confirmation that inflation is a non-stationary process.

The crucial issue, and result, of this research is that inflation has a persistent impact on a real variable which in our case is the markup. It is a moot point whether the ‘persistence’ represents a ‘long-run’ relationship in the sense used by economic theorists (i.e. the value that the markup would converge to after an infinite period of time with constant inflation and other non-markup real variables at their long-run values). However, we can say that the ‘persistence’ does satisfy the standard tests of a ‘long-run’ relationship in the sense used by econometricians (i.e. in the Engle and Granger 1987 sense). Furthermore, from the point of view of macro-policy, the persistence represents a long enough period of time for it to be important.

Finally, it is acknowledged that the 1970s data plays an important role in allowing the long-run relationship to be identified. If the inflation and markup data are stationary with a constant mean then no long-run relationship can be identified in the data *even if the variables are related when the data is non-stationary.* From this perspective, the 1970s provides the data so that inflation is a non-stationary process and the relationship can be investigated in a meaningful way.

4 EXPLAINING THE NEGATIVE INFLATION-MARKUP RELATIONSHIP

There is an extensive literature on the inflation-markup relationship that is written within the framework that either explicitly or implicitly assumes that inflation is a stationary variable.[13] Consequently, the literature does not consider the impact on the markup of a ‘permanent’ change in the mean rate of inflation. Furthermore, these models either explicitly or implicitly assume ‘money neutrality’ and so inflation cannot have a permanent impact on a real variable (i.e. the markup) in the long-run.

In contrast, Russell, Evans, and Preston (2002), Chen and Russell (2002) and Russell (1998) provide explicit explanations of the long-run relationship. The first paper argues that due to missing information, firms do not know the profit maximising price and markup. Firms also believe for a number of reasons that they face an asymmetric loss function such that setting a ‘high’ markup (and price) relative to the profit maximising values costs the firm more than setting a ‘low’ markup.

[13] In the Mankiw (1985) and Parkin (1986) menu cost tradition see Rotemberg (1983), Kuran (1986), Naish (1986), Danziger (1988), Konieczny (1990) and Bénabou and Konieczny (1994). Alternatively see Athey, Bagwell and Sanichiro (1998) for an indirect explanation or Bénabou (1988, 1992) and Diamond (1993).

The asymmetry may be due to a number of reasons. First, firms may trade in a customer market.[14] In this case the impact on the firm of setting a 'high' markup (i.e. a high price) cannot simply be reversed by setting the profit maximising markup in the following period. Having set a 'high' markup, some customers search for relatively lower prices associated with a low markup which, if found, they will accept. The lost customer cannot be induced back to the old supplier by a reduction in the old supplier's markup because the impetus to search is now triggered by the new supplier and not the old supplier. Without the new supplier inducing further search by raising their markup, the lost customer will not search and find that the prices offered by their old supplier have fallen. A 'high' markup, therefore, may have a long term and large impact on the number of customers while a 'low' markup has little impact. A second reason is that firms may believe they face a 'kinked' demand curve.[15] Setting a high markup, therefore, will have a larger impact on output and profits than setting a 'low' markup. A third reason is that firms may face increasing returns to scale. In this case, the impact of a 'high' markup on output reduces profits by more than the impact of a 'low' markup on output.[16]

Consequently, if firms believe they face an asymmetric loss function then, in an uncertain economic environment, firms will set a 'low' markup (and price) relative to their profit maximising values to avoid the disproportionately bad outcome of mistakenly setting a 'high' markup (and price). Finally, if uncertainty increases with inflation then firms will set a lower markup with higher inflation.

The remaining two papers focus on the difficulties that firms face when attempting to coordinate price changes in an inflationary environment.[17] Chen and Russell (2002) argue that disequilibrium from the profit maximising markup imposes two forms of costs on the firm. First there are the lost profits when in disequilibrium. Second there is the expected cost

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[14] For customer markets see Okun (1981) in particular, but also McDonald and Spindler (1987), Bils (1989), McDonald (1990).

[15] For 'kinked' demand curves see Sweezy (1939), Hall and Hitch (1939), Stigler (1947, 1978), Maskin and Tirole (1988).

[16] A further interpretation of the asymmetric loss function is that it simply reflects risk averse firms.

[17] Not withstanding the many possible coordination failures that firms may experience, these two paper only considers the non-synchronous change in prices in response to generalised cost and price inflation. A number of authors highlight the inability of firms to coordinate price changes. For example, see Ball and Romer (1991), Eckstein and Fromm (1968), Blinder (1990) and Chatterjee and Cooper (1989).

of poor price coordination between firms as prices adjust back to the profit maximising markup. It is argued that firms in an uncertain economic environment will choose the speed of price adjustment that minimises the expected loss while in disequilibrium. The expected loss is the sum of the lost profits in disequilibrium and the expected cost of coordination failure.

The speed of price adjustment impacts on the expected loss in two ways. The faster the speed of adjustment the lower the adjustment cost in terms of lost profits. However, the faster the speed of adjustment the greater the probability of coordination failure between firms as they adjust prices. Therefore, a firm that is optimally choosing the speed of adjustment will increase the speed of adjustment until the marginal benefit to the firm in terms of lower adjustment costs just balances the marginal cost due to the increase in the expected cost of coordination failure. As might be expected, the speed of adjustment increases with the size of the disequilibrium from the desired markup and falls with the cost of coordination failure. An important result is that unless the probability of coordination failure is insensitive to the speed of price adjustment then firms will adopt a 'gradualist' approach to price adjustment when in disequilibrium.[18] Consequently, the model in this paper displays nominal price inertia. If the firm operates in an inflationary environment then one can imagine an 'equilibrium' between the firms adjusting prices back to the profit maximising markup and the repeated negative shocks to the markup due to the inflationary environment.

The model in this paper predicts that higher inflation leads to a lower markup unless the expected cost of coordination failure is insensitive to the speed of price adjustment. Higher inflation increases the cost of adjustment in terms of lost profits during disequilibrium and the firm responds by increasing the speed of price adjustment. However, while the increase in the speed of adjustment reduces the loss in profits it simultaneously increases the probability of coordination failure. Consequently the speed of adjustment does not increase by enough to maintain the level of the markup and the markup falls with higher inflation. The lower markup with higher inflation can be interpreted as the higher cost to firms of overcoming the missing information that may cause the coordination failure. Importantly, it is argued that

[18] The assumption that underpins the 'gradualist' price adjustment is similar to the assumption of speed-dependent adjustment costs in the investment literature following Eisner and Strotz (1963) that leads to partial, or 'gradualist', adjustment behaviour by firms except that in this case the adjustment costs are the expected costs of adjustment.

this relationship will persist in the steady state as the missing information is not of a type that can be overcome by knowing the average rate of aggregate inflation.[19]

The second paper that focuses on the difficulties that firms face when coordinating price changes is Russell (1998). This paper considers what happens if non-colluding price setting firms follow a 'price rule' so as to overcome missing information concerning how to coordinate price changes with competitors.[20] The firm's objective with the price rule is to avoid the cost of price coordination failure due to non-synchronous price adjustment in an inflationary environment. The price rule conforms to two assumptions concerning the pricing behaviour of firms for given trading conditions. The first is, the lower the markup the greater the increase in prices set by firms. The second is, firms do not instantly and fully increase prices in response to an increase in unit costs. That is, an increase in unit costs leads initially to a fall in the markup.

The paper proceeds to show how the price rule leads firms in an inflationary environment to synchronise their price increases before considering the steady state properties of the price rule. The model suggests that higher inflation is associated with a lower markup in the steady state. However, the relationship is non-linear. At zero steady state inflation, the markup is at a maximum and, as inflation increases, the markup declines and converges on some minimum value. The declining markup as inflation increases in the steady state is interpreted as the cost to firms of overcoming the missing information when trying to coordinate changes in prices. While the cost of avoiding price coordination failure increases with inflation, it does so at a declining rate.

An important question is whether these papers describe a relationship between the markup and inflation that will persist in the steady state. The relationship will only persist if the uncertainty due to the missing information also persists in the steady state. If the uncertainty is due to firms not knowing the average rate of inflation then uncertainty will disappear in the steady state and any short-run relationship between inflation and the markup will also disappear. In a price-taking model with perfectly competitive firms, this may well be a good characterisation of the uncertainty faced by firms. To maximise profits, firms simply need to accurately predict the price level so that they can set the profit maximising level of output.

19 The steady state is defined as all nominal variables growing at the same constant rate.

20 The rules are formal, or following Machlup (1946), the 'feel' of the businessman.

However, for price-setting firms this may be a poor characterisation of uncertainty. Uncertainty may be more than just not knowing the average rate of inflation. For price-setting firms, the uncertainty may be due to the difficulty in coordinating price changes in an inflationary environment and the profit maximising price is unknown. This difficulty may persist even when firms are aware of the average rate of inflation and, therefore, the relationship between inflation and the markup may also persist in the steady state. Furthermore, price-setting firms must respond to higher inflation by changing prices more often, by larger amounts in real terms, or by some combination of these responses. These responses are likely to increase the difficulty of coordinating price changes. Therefore, uncertainty is likely to increase with inflation as the firm's difficulty in coordinating price changes also increases.

Finally, these three papers argue explicitly that there is a negative relationship between the markup and steady state rates of inflation that may be thought of as a long-run relationship. The lower markup associated with higher inflation in these papers is interpreted as the cost to firms of overcoming the missing information when setting prices in an inflationary economic environment.

5 POLICY AMD OTHER ISSUES

5.1 Real Wage Shocks and the Implications for Monetary Policy

Given the price setting nature of the explanations of the negative relationship between inflation and the markup it follows that we consider the implications from the perspective of a Layard / Nickell macroeconomic model where firms set prices and bargain with labour over wages.[21]

The negative long-run relationship between inflation and the markup implies there is a positive relationship between inflation and the real wage relative to productivity. This suggests there is a role for the monetary authorities in the interaction between employed labour and firms in the wage outcome for the following reason.

Consider an economy that is in the long-run equilibrium at A in Figure 1 where monetary policy is consistent with a long-run rate of inflation $\overline{\Delta p}_A$ and the curve LR represents the

[21] See Layard and Nickell (1991) and Carlin and Soskice (1990).

long-run relationship between inflation and the markup. If the economy experiences a push by employed labour for higher real wages relative to productivity then in the short-run the economy may move to a position such as *B* where inflation is higher and the markup is lower due to lags in price adjustment.[22] We can now consider the impact of the monetary authorities on inflation and the markup.

If the monetary authorities do not loosen policy and monetary policy remains consistent with $\overline{\Delta p}_A$ then the economy will eventually return to *A*. One adjustment mechanism that might occur is in the labour market where the higher real wages and real interest rates leads to an increase in unemployment that causes real wages to fall and the markup recovers to its pre-shock level.[23] Another adjustment mechanism, it that price setting firms will eventually pass through the labour cost increases to achieve their desired markup for the given rate of long-run inflation, $\overline{\Delta p}_A$.

Alternatively the monetary authorities may respond to the real wage shock and the associated increase in unemployment by loosening monetary policy to $\overline{\Delta p}_C$. In this case the economy converges on *C* where the markup is lower but the real wage and inflation are higher. The third alternative is that the monetary authorities partially loosen policy in response to the shock and the economy converges on some intermediate long-run equilibrium such as *D*.

If we assume that the welfare of employed labour includes real wages and unemployment then it follows that the only time consistent (or credible) monetary policy is one where policy is not loosened following the shock to real wages. In this case the welfare of the employed has unambiguously not increased as the real wage is unchanged in the new long-run following the wage shock and unemployment is either higher or unchanged. If policy is loosened following the shock then employed labour is rewarded by a higher real wage in the new long-run providing an incentive for further real wage shocks in the future.

We may also consider what motivates employed labour to push for higher real wages relative to productivity. If employed labour pushes for higher real wages then they must do so with

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22 A similar analysis can be undertaken in response to a positive oil price, import price, tax or general cost shock.

23 This assumes no change in the level of productivity between the initial and final long-run equilibrium. If the lower level of employment increases the marginal product of labour then at *A* productivity in the new long-run may be higher along with the real wage and unemployment. However, the relationship between the markup and inflation will be unchanged.

the expectation that the monetary authorities will respond by at least partially loosening monetary policy so that real wages remain higher in the new long-run equilibrium. Presumably this expectation is based on the past behaviour of the monetary authorities in response to previous wage shocks. Therefore, the only time consistent monetary policy that avoids creating the incentive for further real wage shocks is one where the monetary authorities do not loosen policy following a shock to real wages.

This argument can be contrasted with Friedman (1968) where money growth (or inflation) rules for monetary policy are justified on the grounds that the short-run costs of adjustment back to the long-run are reduced. The implications of the inflation-markup model is that an inflation target will reduce the costs associated with changes to the *long-run* rate of inflation.[24] Friedman (1968) also argues that it is stability in the rate of money growth that is important and not the level of money growth or the level of inflation. A further contrast, therefore, is that the inflation-markup model suggests that a low inflation target is preferable to a high inflation target if a high profit share is preferable to a low profit share.

The desirability of a low inflation target does not imply that there is no role for counter-cyclical macroeconomic policies following aggregate demand shocks. For example, a reduction in aggregate demand will lead to lower inflation allowing some room to loosen macroeconomic policy.

5.2 Competition and the Long-run Relationship

One might argue that the long-run relationships in Graph 1 will be steeper the higher the level of competition. In a perfectly competitive (price taking) world there is no relationship between inflation and the markup and the markup is dependent on 'real' factors alone. In this case the long-run curve in Graph 1 would be vertical and $\lambda = 0$ in equation (1). One might conclude that the steeper the LR curve the closer the economy approximates perfect competition.

There is some difficulty, however, in making the argument too simple. While competition is a nebulous concept it is often argued that competition increases with the number of firms in an industry. The implication is that the economy better approximates the perfectly competitive case as the number of firms increase. A further implication is that there is a

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24 These arguments are treated in more detail in Russell (1996), Russell *et al.* (2002) and Chen and Russell (2002).

continuous spectrum of competitive states based on the number of firms from a monopoly with one firm to perfect competition with a large number of firms. However, this ignores the complications introduced by considering price setting rather than price taking firms. It also ignores the underlying source of the long-run relationship proposed in the papers outlined in Section 4 which is the uncertainty due to missing information and the threat of failing to coordinate price changes in a price setting world.

By assuming that an increase in the number of firms leads to a closer approximation to perfect competition in a price setting world with uncertainty and missing information one must also assume that more firms not only reduces market power but simultaneously *reduces* uncertainty and missing information. While the former is likely to lead to a reduction in the level of the markup, the latter does not necessarily follow with price setting firms. It is more likely that an increase in the number of firms leads to an increase in uncertainty because it is more difficult to coordinate price changes. More firms and greater competition, therefore, leads to an increase in uncertainty and a flatter (and not steeper) long-run curve in Graph 1.

It follows, therefore, that a reduction in the number of price setting firms increases the slope of the long-run curve until in the limit the economy is made up of only monopolies and the uncertainty concerning coordinating price changes disappears (assuming no other source of price uncertainty). Consequently the long-run curve is vertical. This is the opposite conclusion to that when firms are perfectly competitive when more firms lead to a vertical long-run curve.

This apparent contradiction can be resolved by recognising that the amount and type of competition affects both the level of the markup and the slope of the long-run curve as demonstrated in Figure 2. The two limiting cases are shown in the diagram. The first is labelled LR_{PC} and represents perfect competition where the long-run curve is vertical and $\lambda = 0$. With price-taking firms, increasing the number of firms implies an increase in the level of competition and this rotates the long-run curve, LR, in a clockwise direction while simultaneously lowering the mean value of the long-run markup for a given range of inflation.

The second limiting case is for a monopoly. The theories outlined in Section 4 that can explain the long-run curve imply that inflation has no impact on the markup of a monopoly in the long-run as there is no opportunity for price coordination failure between firms.[25] In this

[25] This assumes that there is no other source of inflation related price uncertainty for a monopoly.

case the inflation cost coefficient is also $\lambda = 0$ and the long-run curve is vertical (labelled LR_M in Figure 2) and the long-run markup is greater than in the perfectly competitive case.

In the case of a monopoly, an increase in the number of firms and in the level of competition would see a reduction in the slope of the long-run curve as the long-run curve rotates in an anticlockwise direction and the mean value of the curve for a given range of inflation falls. If at some point firms behave as price-takers, increasing the number of firms and competition will no longer reduce the slope of the long-run curve and the slope will increase as the long-run curve rotates in a clockwise fashion. However, the mean value of the markup will continue to fall with increasing competition.

This discussion suggests two things. First, the size of the inflation coefficient depends in part on industry structure. Second, as one moves through the spectrum of competition from monopoly to perfect competition, at some point the relationship between competition and the inflation coefficient reverses and this point will depend on the technology and nature of the industry itself. Consequently there is no monotonic relationship between the number of firms or measures of competition and the inflation coefficient.

5.3 Independent Central Banks and Inflation Targeting

The inflation-markup relationship suggests that there are benefits that accrue to those who control the setting of monetary policy. For example, governments that represent employed labour will desire higher inflation as it lowers the markup so that the real wage of the workers increase relative to productivity. In contrast, governments representing firms will desire lower inflation so as to increase the profit share. In many ways the present world-wide move towards inflation targeting and central bank independence can be seen as an institutional framework designed to reduce the volatility in the setting of monetary policy (in terms of shifts in the implicit target rate of inflation) that is introduced when the economic group that controls the central bank (i.e. the government) changes.

The slope of the long-run relationship also has a number of implications for the monetary policy framework. First, the flatter the long-run curve the greater the perceived benefits for the monetary authorities of targeting low inflation. This is because the flatter the long-run curve the greater the impact on the markup of a change in inflation and so the greater the benefits in terms of higher investment and employment. Second, the flatter the long-run curve the more important it is for the monetary authorities to be independent of the political process. This is because the returns to employed labour and firms of influencing monetary policy are higher with a flatter long-run curve. Consequently to avoid large shifts in monetary policy the monetary authorities need to be independent of employed labour and firms.

5.4 The Capital Markets

If capital markets are imperfect then the markup may influence investment and the size of the capital stock due to the impact of the markup on the availability of internal funds.[26] Higher inflation lowers the markup and reduces the ability of firms to fund investment through internal funds leading to a lower capital stock in the long-run.[27] This implies that the growth path of the capital stock is lower with higher inflation and presumably the growth path in output per capita is also lower. However, the rate of growth in output per capita is unaffected in the long run as it is determined by the rate of technical progress only that it is on a lower growth path.

6 CONCLUSION

In summary the contribution of this research programme to our general understanding is twofold. First, until this research, the literature ignores how persistent the impact of inflation is on the markup. Instead standard economics downplays the importance of the relationship because it is thought the impact is only fleeting. Consequently, the important implications for the economy of a persistent decrease or increase in the markup during long periods of high or low inflation are ignored in the literature so far. Second, the research programme provides an important avenue for understanding how monetary policy should be set and how the institutional framework for the setting of monetary policy has developed.

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[26] Fazzari *et al.* (1988) argue the cost to firms of internal funds is less than external funds and shows empirically that investment is influenced by the availability of internal finance.

[27] Pindyck and Solimano (1993) offer three explanations why internal funds may influence investment. They also show for a number of countries that investment is negatively correlated with inflation.

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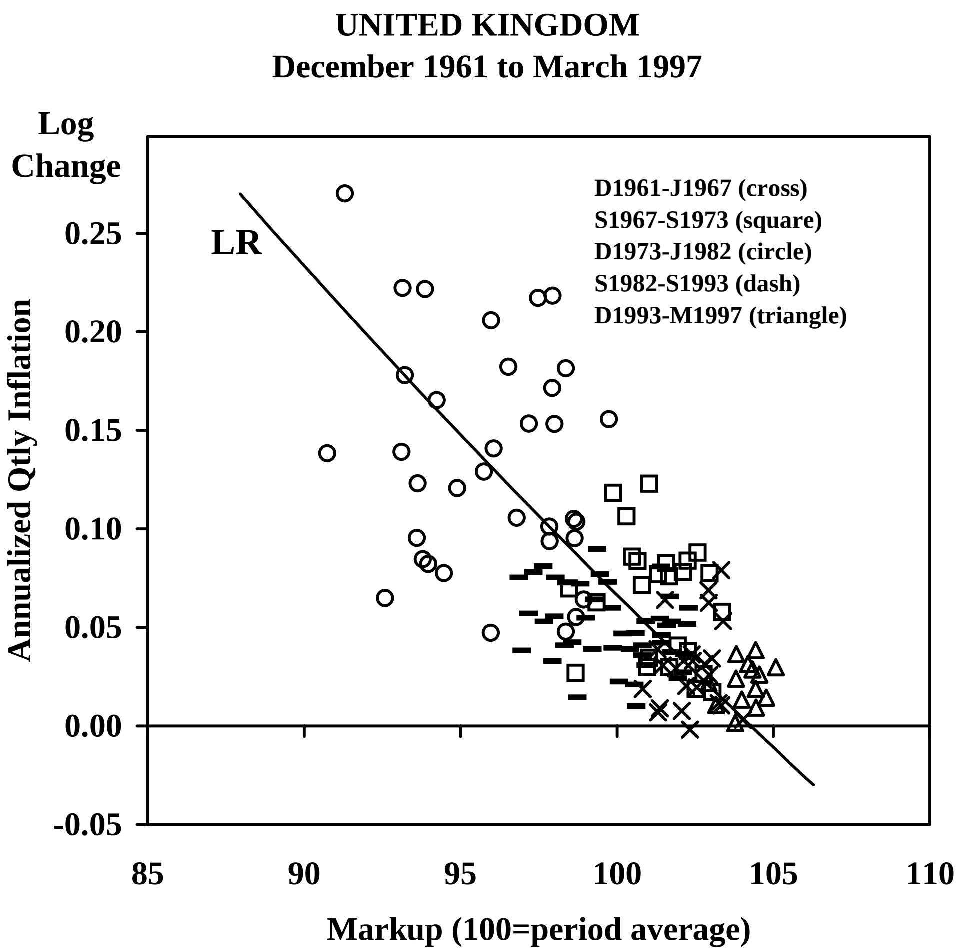
Graph 1*



Banerjee and Russell (2001a) page 382.

Figure 1: Real Wage Shocks and Monetary Policy

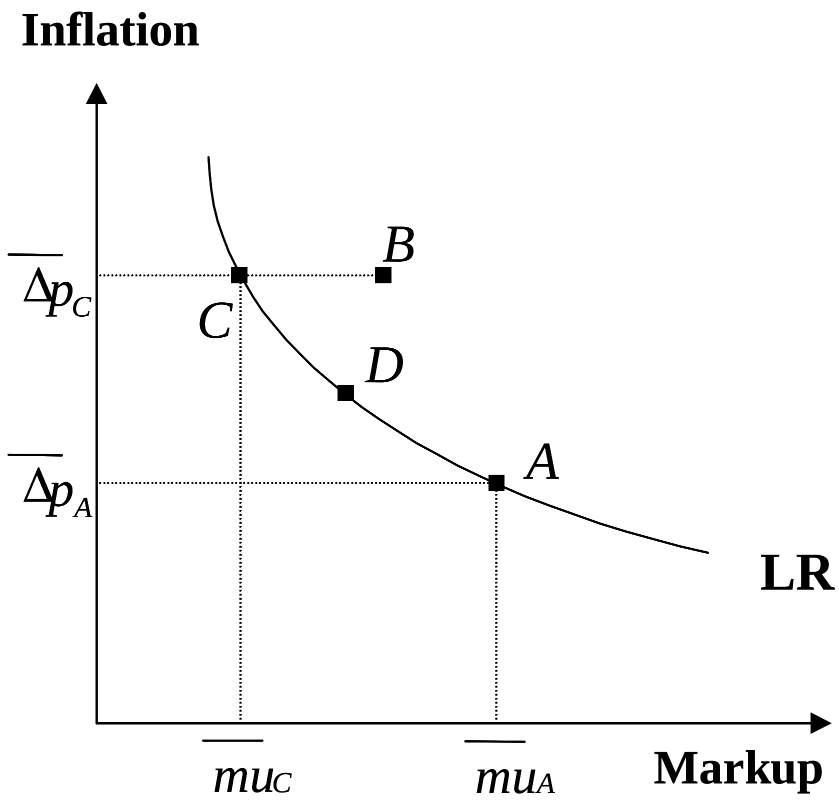
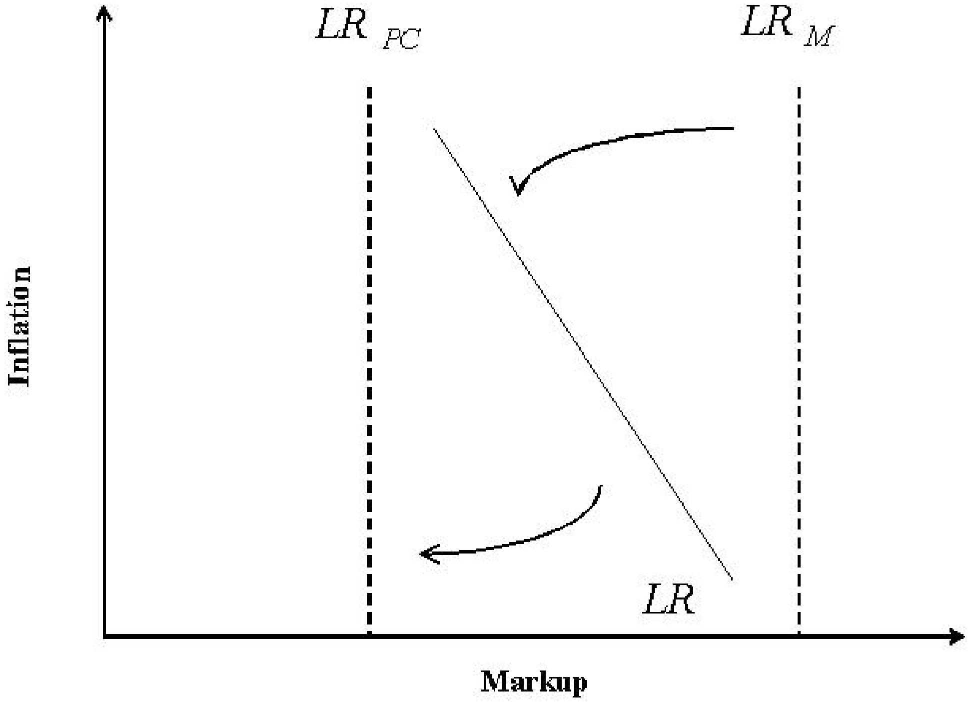


Figure 2: Competition and the Long-Run Relationship



Note: The arrows indicate the impact on LR of an increase in the number of firms and competition.

Table 1: Estimates of the negative long-run inflation-markup relationship assuming inflation is integrated of order 1

The long-run relationship is written $mu_t = q - \lambda \Delta p_t$ where mu_t is the estimated markup of price on unit costs 'net' of the costs of inflation, Δp_t represents inflation, q is the 'gross' markup, and λ is a positive parameter and is termed the 'inflation cost' coefficient. Lower case variables are in natural logs. The inflation cost coefficient is equivalent to the decrease in the markup associated with a 1 percentage point increase in the annual rate of inflation.

Paper	Country	Data[1]	Frequency	Inflation Coefficient, λ [2]
Banerjee, Cockerell & Russell (2001)	Australia	March 1972 to June 1995, EWD.	Q	I(1) model: 1.8 I(2) model: 1.8
Banerjee & Russell (2001a)	United States	December 1961 to June 1997, EWD.	Q	I(1) model: 0.5 I(2) model: 0.3
	Germany	March 1971 to December 1994, EWD.	Q	I(1) model: 1.2 I(2) model: 0.9
	France	December 1971 to March 1997, EWD.	Q	I(1) model: 0.7 I(2) model: 0.7
	Italy	March 1972 to March 1997, EWD.	Q	I(1) model: 2.0 I(2) model: 2.0
	United Kingdom	December 1961 to March 1997, EWD.	Q	I(1) model: 0.6 I(2) model: 0.6
	Canada	March 1962 to March 1997, EWD.	Q	I(1) model: 1.1 I(2) model: 1.1
	Australia	March 1967 to March 1997, EWD.	Q	I(1) model: 1.3 I(2) model: 1.4
Banerjee & Russell (2001b)	United States	1947 to 1997. Private industry data. Results of industry data are for 'market based' industries where inflation is I(1).	A	Total private industry: 0.6 Industry results: 1.1, 0.7, 2.8, 2.0, 1.4, 4.6, 5.2, 1.4, and 1.0.
Banerjee & Russell (2004)	United States	December 1952 to March 1989. Private sector data (i.e. excluding government).	Q	I(1) model: 0.8
Banerjee & Russell (2005)	United States	June 1953 to March 2000. Private sector data (i.e. excluding government).	Q	I(1) unit cost markup model: 0.6 I(1) marginal cost markup model: 1.7
Russell & Banerjee (2006)	Euro Area	June 1973 to March 2002, EWD.	Q	I(1) model: 1.2
Banerjee, Mizen & Russell (2002)	United States	June 1968 to June 2001, private sector data.	Q	I(1) model: 1.6
	United States	1950 to 1997, private sector data.	A	I(1) model: 1.5
	United Kingdom	June 1964 to March 2001, EWD.	Q	I(1) model: 1.1
	United Kingdom	1951 to 1999, EWD.	A	I(1) model: 0.4

(1) EWD is economy wide data. (2) Estimates of λ using quarterly data are multiplied by 0.25 to give the implicit annual value of λ. The I(1) model estimates the long-run equation directly using the markup and inflation. The I(2) model assumes that prices and costs are I(2) variables and freely estimates the markup and λ simultaneously.

Table 2: Implicit estimates of the negative long-run inflation-markup relationship from previously published work

Paper	Country	Data and Notes on Estimation[1]	Implicit Inflation Coefficient, λ
Franz and Gordon (1993)	United States	Quarterly data, June 1962 to December 1990, EWD. The paper estimates error correction models of inflation where the ECM is equivalent to the markup. From table 7 we see the short-run impact of the ECM (markup) on inflation is – 0.07. We can solve for the implicit long run relationship by assuming inflation is constant such that: $\Delta p = \frac{-0.07}{1-0.78} ECM = -0.31 ECM$ where Δp is inflation and ECM is the error correction term. Inverting the estimated equation and dividing by 4 (to give the annual inflation cost coefficient), the implicit $\lambda = 0.79$. This can be compared with the United States results from Table 1 above of 0.3, 0.5, 0.6, 0.8, 0.6, 1.5 and 1.6.	0.8
	Germany	Quarterly data, June 1962 to December 1990, EWD. Calculating the long-run inflation cost coefficient in the same was as above for the United States then $\lambda = 0.08$. This can be compared with the German result from Table 1 above of 0.9 and 1.2.	0.1
Cockerell & Russell (1995)	Australia	Quarterly data, June 1972 to September 1973, EWD. The paper estimates simultaneously error correction models for wage and price inflation where the error correction term is equivalent to the markup. The paper solves for the steady state relationship between inflation and the markup and reports on page 23 that a 1 percentage point increase in annual steady state inflation leads to a fall in the markup of 1 1/3 per cent. The implicit inflation cost coefficient is therefore $\lambda = 0.75$. This can be compared with the Australian results from Table 1 above of 1.3, 1.4, and 1.8.	0.8
de Brouwer & Ericsson (1998)	Australia	Quarterly data, June 1972 to September 1973, EWD. An implicit inflation cost coefficient, $\lambda = 2.8$, can be calculated from the results reported in equation (10) on paper 438 by setting petrol price inflation equal to price inflation in the long run. This can again be compared with the Australian results from Table 1 above of 1.3, 1.4, and 1.8.	2.8
Batini, Jackson & Nickell (2000)	United Kingdom	September 1972 to June 1999, EWD. The estimation is in terms of the natural logarithm of labour's income share which is equivalent to minus the natural logarithm of the markup. Taking the 'baseline' results of Table 7a (page 32) we see the short-run impact of labour's income share on inflation is 0.16. In the long run with inflation is a constant rate we can solve the estimated equation such that: $\Delta p = \frac{0.16}{1-0.69} s^* = 0.51 s^*$ where Δp is inflation and s^* is labour's income share. Inverting the estimated equation, taking the negative (to get the relationship with the markup) and dividing by 4 (to give the annual inflation cost coefficient), the implicit $\lambda = 0.5$. This can be compared with the United Kingdom results from Table 1 above of 0.4, 0.6 and 1.1.	0.5

(1) EWD is economy wide data